Integrated Mosquito Management: No New Thing

To the Editor: Rose displays a fundamental misunderstanding of the history of mosquito control when he states, "Mosquito control in the United States has evolved from reliance on insecticide applications for control of adult mosquitoes (adulticide) to integrated pest management programs that include surveillance, source reduction, larvicides, and biological control, as well as public relations and education" (1).

More than 100 years ago, General William C. Gorgas used a multifaceted approach to control mosquitoes when he and his staff brought yellow fever under control in Havana after the Spanish-American War. He was to repeat this approach in Panama, where the French had lost 20,000 lives to mosquito-borne disease in their failed attempt to construct an isthmusian canal.

In New Jersey at the turn of the century, state entomologist John B. Smith was convinced that the state could be made mosquito free. The laws of 1902 provided for funding to study mosquitoes and resulted in Smith's comprehensive study of the subject (2). Smith's work led to water management as a primary means of controlling mosquitoes on New Jersey's extensive salt marshes. He addressed the issue of biological control by native fish, primarily saltmarsh killifish. Thus, Rose's claim is inaccurate: Integrated mosquito management (IMM) was alive and well at the turn of the century.

When the New Jersey Mosquito Extermination Association was formed in 1913, state mosquito control workers began what has been a long involvement with education and public relations. These critical components of IMM have long been an essential part of mosquito control activities throughout the United States. Reports by various county control agencies in New Jersey reveal an ongoing concern with water management. Indeed, these early reports speak of water management, particularly in the upland environment, as a means of making lands formerly considered useless productive and thus generators of tax revenues.

Regarding surveillance, the laws of 1905 charged the director of the New Jersey Agricultural Experiment Station with conducting surveys of mosquito breeding in the various political entities of the states. The standard tool for surveillance, the New Jersey light trap, was developed in the 1930s and has been in regular use since then. Thus, another key component of IMM was in place at the turn of the last century.

IMM has long been the standard operating procedure in New Jersey and many other states. In the early 20th century, mosquito fighters did not have the array of weapons now available. They had to use the tools available to them: sanitation, habitat management, larvicides, fumigation for adults, screens for exclusion, education, and legal action (i.e., fines for maintaining mosquito-breeding sites on private property).

The association between mosquitoes and disease was very real in the early days of mosquito control. As recently as 1880, 20,000 lives were lost to malaria in the Mississippi River Valley, and malaria was endemic in the Tennessee Valley. Mosquito control in the Tennessee Valley Authority area was not brought about by mosquitocides but by clear-cutting the margins of bodies of water to reduce or eliminate mosquito habitat. The wide-scale use of mosquitocides did not occur until after World War II. Before then, IMM was the only response they had. To ignore these facts does a grave disservice to those who fought in the mosquito wars in the early part of the 20th century.

I also disagree with Rose's discussion of some biological control agents. One has only to look at the number of mosquitoes coming off a flooded high tidal marsh to realize that biological control is useful primarily in areas where mosquito populations do not result in thousands of mosquitoes per trap night. Similarly, some of the limitations listed for various mosquitocides are givens. Mosquito control workers know full well there is no panacea; that is the reason for IMM. It is erroneous, for instance, to list subsurface larvae as a limitation for monomolecular films; where a monomolecular film is present, subsurface larvae cannot emerge because the reduced surface tension does not allow the newly emerged adult to stand on the water's surface. An insect landing on treated water passes through the surface and drowns. Indeed, the greatest drawback of monomolecular films is their effect on insects that require a certain amount of surface tension, such as water striders.

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References

1. Rose RI. Pesticides and public health: integrated metehods of mosquito management. Emerg Infect Dis 2001;7:17-23.
2. Smith JB. Report of the New Jersey Agricultural Experiment Station upon the mosquitoes occurring within the state, their habits, life history, etc. New Brunswick (NJ); 1904. Cited in Headlee TJ. The mosquitoes of New Jersey and their control. New Brunswick (NJ): Rutgers University Press; 1945.

Integrated Mosquito Management—Reply to Dr. Rupp

To the Editor: My article (1) was not intended to delve into the history of mosquito control nor cast aspersions on the great work that was done to fight malaria and yellow fever a century ago. Rather, the article is a short review of contemporary integrated methods of mosquito management and a discussion of how public health pesticides may be affected by the Food Quality Protection Act's amendments to the Federal Insecticide, Fungicide, and Rodenticide Act.

Mr. Rupp contends that the article misinterprets the history of mosquito control and does a disservice to those who fought in the mosquito wars in the early 20th century. Mr. Rupp valiantly defends this early history in his letter,

with reference to programs a hundred years ago, when contemporary pesticides and biological and cultural controls did not exist and the tools of mosquito control were limited to such measures as deep-ditch draining of wetlands in New Jersey, clear-cutting, and use of arsenic compounds and crude petroleum for larval control. Deep-ditch draining was also practiced long ago in other states, such as Florida.

It was but half a century ago, after World War II, that chlorinated hydrocarbons such as DDT came into widespread use for mosquito control until they were banned, and organophosphates such as malathion and naled took their place. For cost and performance reasons, DDT continues to be used in several developing countries for mosquito control. Mr. Rupp refers to old reports of water management as a means of making land formerly considered useless into productive land capable of generating tax revenues. Today, this practice would be considered wetlands conversion and wildlife habitat destruction.

Robert Ward's article in the latest Florida Mosquito Control Association's Wing Beats reminisces about the venerable thermal fog machine, "those hot smelly 'smokers' belching up to eighty gallons of fog material per hour...fireballs, greasy streets and cars, or blinded drivers" (2). Back in those days, many children chased them on bicycles, ignorant of pesticide risks that are now known. Even in recent history, broad-spectrum organophosphates such as parathion and chlorpyrifos, which have potent nontarget effects, were used in aquatic habitats to control mosquito larvae.

Mr. Rupp's comments focus mainly on the mosquito control of a century ago, when the stakes were high because of malaria and yellow fever. The pioneers in mosquito control did marvelous work with the limited tools available to them and their limited knowledge of environmental consequences, but the history of mosquito control has had its time of pesticide reliance and has truly evolved to today's fully integrated mosquito management as briefly described in the article.

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References

1. Rose RI. Pesticides and public health: integrated methods of mosquito management. Emerg Infect Dis 2001;7:17-23.
2. Ward R. Are we just power mad? Wing Beats 2000;11:25-6.

Enteric Fever Treatment Failures: A Global Concern

To the Editor: We read with great interest the report by Threlfall et al. (1) of decreased susceptibility to ciprofloxacin in *Salmonella enterica* serotype Typhi from the United Kingdom. The authors indicate that nalidixic acid-resistant *S.* Typhi with decreased susceptibility to ciprofloxacin is now endemic in India and neighboring countries, constituting a threat to global health. The data are consistent with previous studies from India (2-4). Despite the wide applications and broad-spectrum efficacy of fluoroquinolones, resistance is increasingly observed in many species of gram-negative organisms, including *Salmonella*. Detection in any part of the world of even a few resistant strains with higher MICs to ciprofloxacin is of concern to clinicians and microbiologists. We report our recent observations in cases of treatment failure of enteric fever caused by *S. enterica* serotypes Typhi and Paratyphi A.

Fluoroquinolones have been in use for >15 years and have remained an extremely important weapon against infections. Ciprofloxacin is used widely in India to treat many human infections, even without prescription, although recommendations limit its use to enteric cases caused by multidrug-resistant (MDR) strains. However, concern is increasing that widespread use of these and newer drugs will result in development of resistance against them. Recently, reports have increased worldwide concerning reduced activity of ciprofloxacin and allied drugs against many infectious agents, including *Salmonella* (2-4).

In an ongoing study of drug susceptibility following E-test, >12% of recent isolates of *S. typhi* in our institution have shown increased MICs to ciprofloxacin (range, 1.0 to 2.0 µg/mL), with 3% as high as 2.5 µg/mL (3,4). Of >100 strains screened recently, 4 of 18 MDR strains had increased resistance to ciprofloxacin. Of the rest, 9 of 82 had higher MICs to ciprofloxacin alone but were not MDR, and 2 were cases of double infection with *S.* Typhi and *S.* Paratyphi A, common serotypes causing enteric fever in our region. Because resistance to the quinolone group of drugs (caused by gene mutations) develops independent of that in other drugs which are plasmid encoded, it also may develop in otherwise sensitive strains.

However, our recent observations differ from those of Dr. Threlfall, as well as from past data from India. We have observed that treatment failures did not always correlate with higher MICs to nalidixic acid and ciprofloxacin alone. We have also noted a declining rate of MDR in *S.* Typhi, reflecting increased sensitivity to chloramphenicol, amoxicillin, and trimethoprim. However, *S.* Paratyphi A showed relatively increased resistance to these drugs. The increasing resistance to ciprofloxacin, to which enteric fever treatment failures are often attributed, is now mainly caused by strains susceptible to other common drugs.

Drs. Threlfall and Ward stated that >50% of strains with decreased susceptibility to ciprofloxacin were MDR (1). In contrast, our findings suggest that, despite prolonged doses of ciprofloxacin, treatment failures are still common with isolates sensitive to ciprofloxacin and nalidixic acid. Drs. Threlfall and Ward also mentioned that MDR cases with reduced sensitivity to ciprofloxacin are mainly transmitted by travelers returning from India and Pakistan. This observation would be justified as long as phage type E1, comprising MDR strains with higher MICs to ciprofloxacin, is endemic in India. However, problems of reduced action by ciprofloxacin are now thought to be independent of MDR, to result from many other factors, and thus to be of global origin and incidence. Overall, we observe a much higher rate than in the past of reduced susceptibility in *S.* Typhi and *S.* Paratyphi A in our region, causing delayed response in enteric patients. The increasing enteric fever treatment failures noted by our clinicians indicate the need for careful screening of recent isolates.

Fluoroquinolone resistance usually results from mutations in genes for drug targets (*gyrA* and *parC*) or resistance is increasingly observed in many species of gram-negative organisms, including *Salmonella*. Detection in any part of the world of even a few resistant strains with higher MICs to ciprofloxacin is of concern to clinicians and microbiologists. We report our recent observations in cases of treatment failure of enteric fever caused by *S. enterica* serotypes Typhi and Paratyphi A.

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References

1. Threlfall EJ, Ward LR. Decreased susceptibility to ciprofloxacin in *Salmonella enterica* serotype Typhi, United Kingdom. Emerg Infect Dis 2001;7:448-50.
2. Chandel DS, Chaudhry R, Dhawan B, Pandey A, Dey AB. Drug resistant *Salmonella enterica* serotype Paratyphi A in India. Emerg Infect Dis 2000;6:420-1.
3. Rodrigues C, Mehta A, Joshi VR. Nalidixic acid resistant *Salmonella typhi* in Mumbai. Nat Med J India 1999;12:188.
4. Chaudhry R, Chandel DS, Mehta G, Kapoor H, Pang T. Molecular characterisation of drug sensitive and drug resistant strains of *Salmonella typhi*. Med J Indonesia 1998; 7(S1):188.
5. Hooper DC. Emerging mechanisms of fluoroquinolone resistance. Emerg Infect Dis 2000;7:337-41.
6. Poole K. Efflux-mediated resistance to fluoroquinolones in gram-negative bacteria. Antimicrob Agents Chemother 2000; 44:2233-41.
7. Cullmann W, Steiglitz M, Baars B, Opferkuch W. Comparative evaluation of newly developed quinolone compounds, with a note on the frequency of resistant mutatants. Chemotherapy 1985;31:19-28.
8. Schentag JJ. Clinical pharmacology of the fluoroquinolones: studies in human dynamics/kinetic models. Clin Infect Dis 2000;31:S40-S44.
9. Borcherding SM, Stevens R, Nicholas RA, Corley CR, Self T. Quinolones: a practical review of clinical uses, dosing considerations and drug interactions. J Fam Pract 1996;42:69-78.
10. Chaudhry R, Laxmi BV, Nisar N, Ray K, Chandel DS. Standardisation of polymerase chain reaction for the detection of *Salmonella typhi* in typhoid fever. J Clin Pathol 1997;50:437-9.

Enteric Fever Treatment Failures—Reply to Drs. Chandel and Chaudhry

To the Editor: We are pleased that Drs. Chandel and Chaudhry support our concern that the development of low-level resistance to fluoroquinolone antimicrobial agents in *Salmonella enterica* serotype Typhi is a threat to health in both developing and developed countries. They cite their article (1) reporting the recent emergence in India of strains of *S.* Paratyphi A resistant to nalidixic acid and with low-level resistance to ciprofloxacin. This finding has also been observed in the United Kingdom, with >30% of *S.* Paratyphi A infections in 2000 being caused by strains with decreased susceptibility to ciprofloxacin. Of these strains, only one was also resistant to other antimicrobial agents.

Our findings and those of Chandel and Chaudhry clearly demonstrate the inadvisability of the use of ciprofloxacin in the Indian Subcontinent to treat many human infections, regardless of prescription. To maintain the efficacy of fluoroquinolones in both developing and developed countries, this class of antimicrobial agents must be reserved for treatment of invasive disease and not for prophylaxis. For travelers visiting developing countries, ciprofloxacin must be used only when absolutely necessary and not for treatment of uncomplicated gastroenteritis or for travelers' diarrhea syndromes.

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Reference

1. Chandel DS, Chaudhry R, Dhawan B, Pandey A, Dey AB. Drug-resistant *Salmonella enterica* serotype Paratyphi A in India. Emerg Infect Dis 2000;6:420-1.